Functional Example AS-FE-I-010-V20-EN

# SIMATIC Safety Integrated for Factory Automation

Distributed use of laser scanner SIMATIC FS600 in category 3 according to EN 954-1: 1996 (with evaluation according to EN 62061 and EN ISO 13849-1: 2006)

safety INTEGRATED

SIEMENS

## Preliminary remark

The Functional Examples dealing with “Safety Integrated” are fully functional and tested automation configurations based on A&D standard products for simple, fast and inexpensive implementation of automation tasks in safety engineering. Each of these Functional Examples covers a frequently occurring subtask of a typical customer problem in safety engineering.

Aside from a list of all required software and hardware components and a description of the way they are connected to each other, the Functional Examples include the tested and commented code. This ensures that the functionalities described here can be reset in a short period of time and thus also be used as a basis for individual expansions.

## Important note

The Safety Functional Examples are not binding and do not claim to be complete regarding the circuits shown, equipping and any eventuality. The Safety Functional Examples do not represent customer-specific solutions. They are only intended to provide support for typical applications. You are responsible for ensuring that the described products are used correctly.

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# 2 Automation Function

## 2.1 Description of the functionality

### 2.1.1 Foreword

**Application areas**

The laser scanner SIMATIC FS600 is used for hazard protection. The laser scanner, aligned horizontally in most cases, monitors the presence of persons in the protected zone.

When using the laser scanner SIMATIC FS600, access to the hazardous location must only be possible through the protected zone. A safe distance must be kept between protected zone and hazardous location. The distance is calculated according to the formulas in the specific machine related European C standards or in the general B1 standard EN 999.

The relevant regulations of machine safety in Europe apply for the use of distance scanners (e.g. laser scanner SIMATIC FS600), in particular:

- machinery directive 98/37/EC
- work equipment directive 89/655/EEC

**Operating principle of the laser scanner SIMATIC FS600**

The laser scanner SIMATIC FS600 is a distance scanner. It sends very short laser pulses and measures the time until the pulse hits an object, as well as its remission (diffuse reflection of a beam by a non-reflecting surface) to the receiver in the laser scanner. The device uses this time to calculate the distance between object and laser scanner. The sensor unit of the laser scanner SIMATIC FS600 rotates and sends/receives a laser pulse after each 0.36°. A circular sector of up to 190° is scanned in the center of which the laser scanner is located.

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## Distributed use of the laser scanner SIMATIC FS600

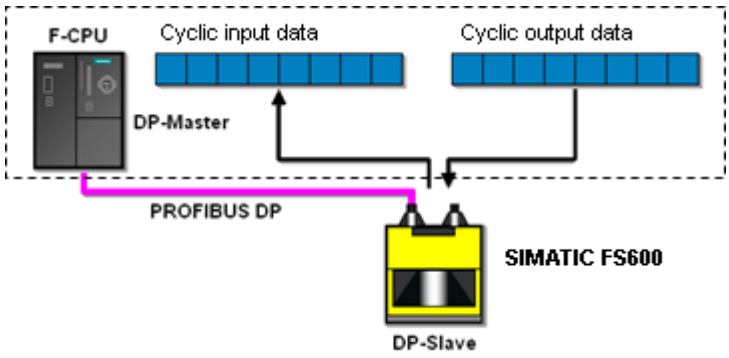
In the “PROFIBUS“ variant, the SIMATIC FS600 laser scanner can be operated as safe bus component together with non-safe standard components on the same bus (PROFIBUS DP). This is enabled by the PROFIsafe protocol, an expansion of PROFIBUS DP. For the user this makes no difference: The SIMATIC FS600 laser scanner is connected to the PROFIBUS in the same way as other DP slaves.

## Communication between F-CPU and laser scanner SIMATIC FS600

The fail-safe S7-CPU (F-CPU) and the SIMATIC FS600 laser scanner communicate via PROFIBUS.

- The laser scanner SIMATIC FS600 provides the F-CPU with cyclic input data of 1 byte length.
- The laser scanner SIMATIC FS600 in return expects from the F-CPU cyclic output data of 1 byte length.

These data can be processed and evaluated in the standard program and in the safety program of the F-CPU.




The terms “input data” and “output data” refer to the view of the DP master (F-CPU):

- Input data are read cyclically out of the laser scanner SIMATIC FS600 by the DP master (F-CPU)
- Output data are written cyclically into the laser scanner SIMATIC FS600 by the DP master (F-CPU)

The STEP 7 project (hardware configuration and sample code) delivered with this safety functional example shows how the cyclic input and output data are integrated into the application program of the F-CPU.

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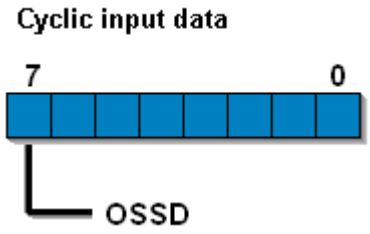
### Bits of the cyclic input data (F-CPU ⇦ laser scanner SIMATIC FS600)

Only the bits required for understanding the entire functionality are explained here.



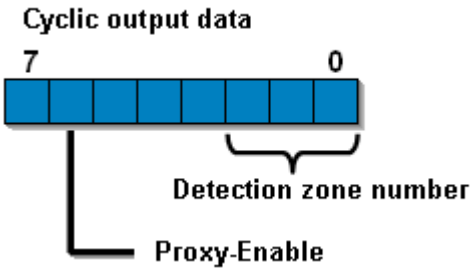

| Bit | Meaning |
|---|---|
| Bit 7: OSSD | The OSSD bit (bit 7) is fail-safe information of the laser scanner SIMATIC FS600. It indicates whether the detection zone has been violated. A signal change from “1“ to “0“ indicates a detection zone violation. In the safety program of the F-CPU, the actuator is switched off as a consequence. |

**WARNING**

**Bits 0 to 6 must not be used for safety relevant decisions. The F-CPU only has to evaluate bit 7 in order to re-enable the actuator if necessary.**

### Bits of the cyclic output data (F-CPU ⇨ laser scanner SIMATIC FS600)

Only the bits which are useful for understanding the complete functionality are discussed here.




| Bit | Meaning |
|---|---|
| Bit 6: Proxy Enable | Setting this bit is important for switching between the detection zones (further information on detection zones are given below). |
| Bit 0, Bit 1, Bit 2: Number of the detection zone | A detection zone pair in the laser scanner SIMATIC FS600 is selected with this bit. |

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## Detection zones and warning zones

When using the laser scanner SIMATIC FS600, you have to define protection and warning zones. A detection zone (SF) and a warning zone (WF) always form a zone pair.

Up to 4 zone pairs can be defined; but only one zone pair may be active at any time. Detection zone numbers (bits 0, 1 and 2 of the cyclic output data) let you define the zone pair (1, 2, 3 or 4) to be active.

The detection and warning zones are defined using the LS4soft configuration and diagnostic software. The PROFIsafe adapter enables correct time behavior when switching the zone pairs. A violation of detection and warning zones is indicated by:

- LEDs at the laser scanner SIMATIC FS600
- Bits of the cyclic input data

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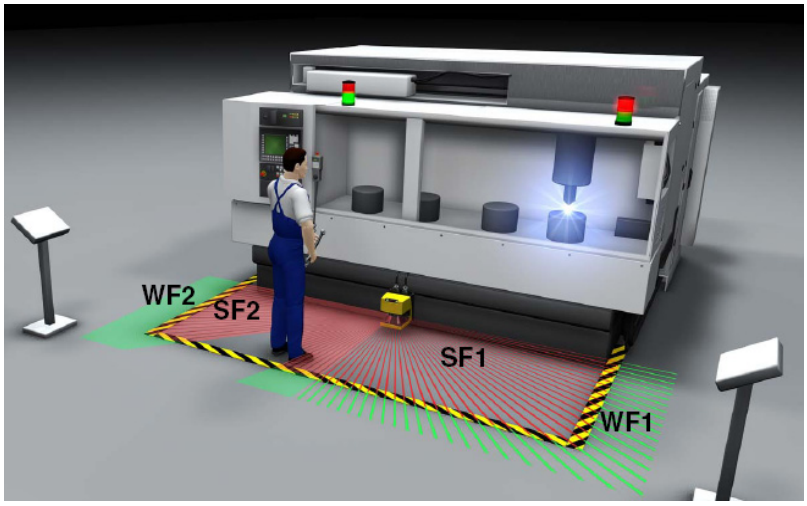
## Example for an active zone pair

The robotic cell shown in the following picture consists of two zone pairs:

| Zone pair | Status in the picture |
|---|---|
| Zone pair 1 (SF1, WF1) | The zone pair is active.<br>If someone trespasses detection zone 1, the robot will stop. |
| Zone pair 2 (SF2, WF2) | The zone pair is not active.<br>It is allowed to enter the area for detection zone 2 and warning zone 2. |



### 2.1.2 Functionality of the safety functional example

The STEP 7 project (hardware configuration and sample code) to the safety functional example comprises the following components:

- fail-safe S7-CPU (DP master)
- laser scanner SIMATIC FS600 for PROFIBUS (DP slave)
- standard and fail-safe input and output modules of ET 200S (DP slave)

In the safety functional example, a hazardous machine is simulated by an indicator light (actuator) which is connected to a fail-safe digital output module (F-DO). The term "machine" will be used to designate the indicator light (actuator) in the following.

If the active detection zone of the laser scanner SIMATIC FS600 is violated while the “machine” is switched on, the “machine” will be switched off automatically (indicator light off). Restarting the “machine” is only possible if an acknowledgement is given first.

The status of the sensors defines the detection zone numbers (bits 0, 1 and 2 of the cyclic output data). It defines which protection and warning zone is active. In the safety functional example, either zone pair 1 (detection zone 1 and warning zone 1) or zone pair 2 (detection zone 2 and warning zone 2) is active. If you want to expand the safety functional example with the aim to work with three or four zone pairs, you can use the prepared program sequences of the sample code (further information given in chapter 6).

The sensors for switching the detection zones are directed to a fail-safe input module of the (F-DI). If this F-DI malfunctions, switching between the detection zones is not possible anymore. This fault is recognized. As a response to this fault, the fail-safe output module (F-DO) is set to fail-safe mode (indicator light switched off).

| NOTICE | **In order to meet the requirements of category 3 / SIL 2, it is obligatory for certain actuators (e.g. contactor) to read back the process signal to the actuator.**<br>**Read-back is not implemented in this safety functional example. The actuator is an indicator light simulating a machine. When using different actuators, the feedback circuits have to be integrated and evaluated by the user. Safety functional example 7 provides a detailed description of “Read back”.** |
|---|---|

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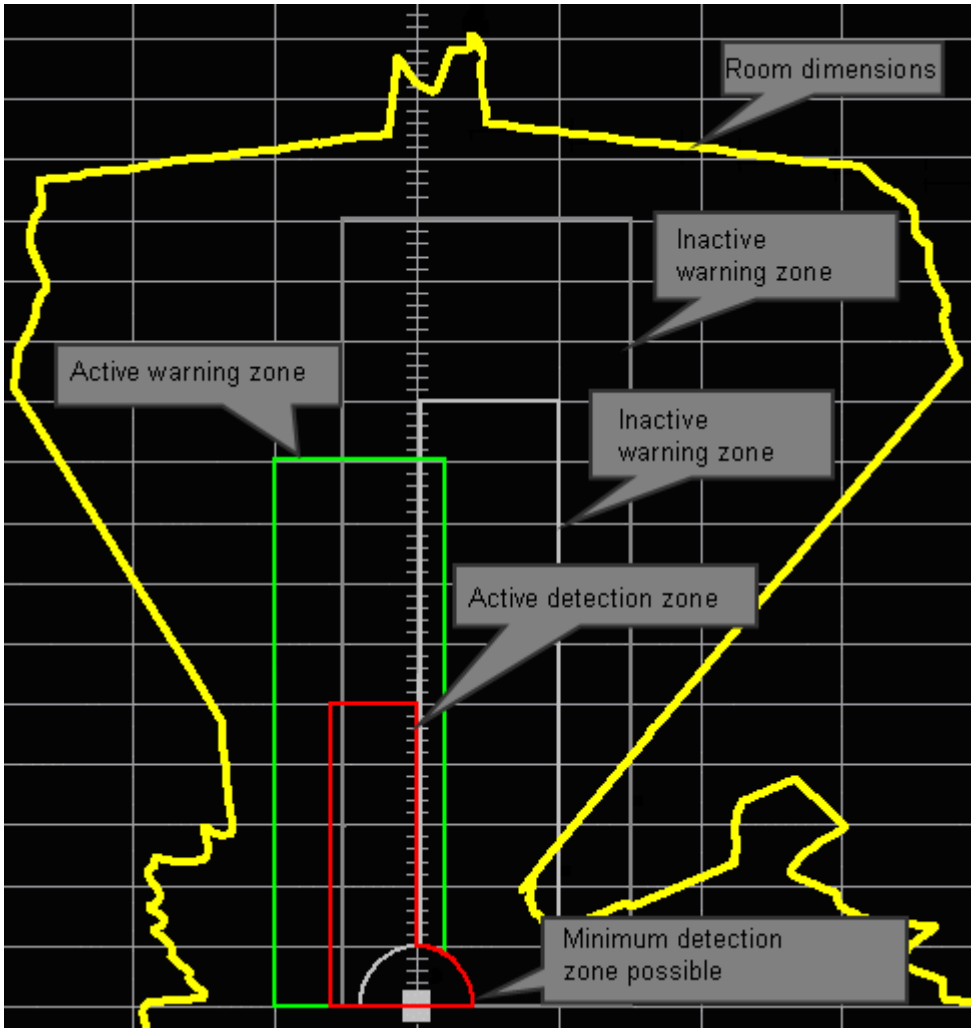
### Parameter set for the laser scanner SIMATIC FS600

The parameter set for the laser scanner SIMATIC FS600 contains the configuration data for the safety functional example. How to load the configuration data into the laser scanner SIMATIC FS600 is described in chapter 4.3. The parameter set for the laser scanner SIMATIC FS600 includes zone pair 1 (detection zone 1, warning zone 1) and zone pair 2 (detection zone 2, warning zone 2). The picture below shows a screenshot from the LS4soft configuration and diagnostics software. You see the two zone pairs.




**Note**

The contours of the protection and warning zones used in the safety functional example are rectangles. The LS4soft configuration and diagnostics software also enables parameterizing other contours (e.g. semi circles) as zone delimiters.

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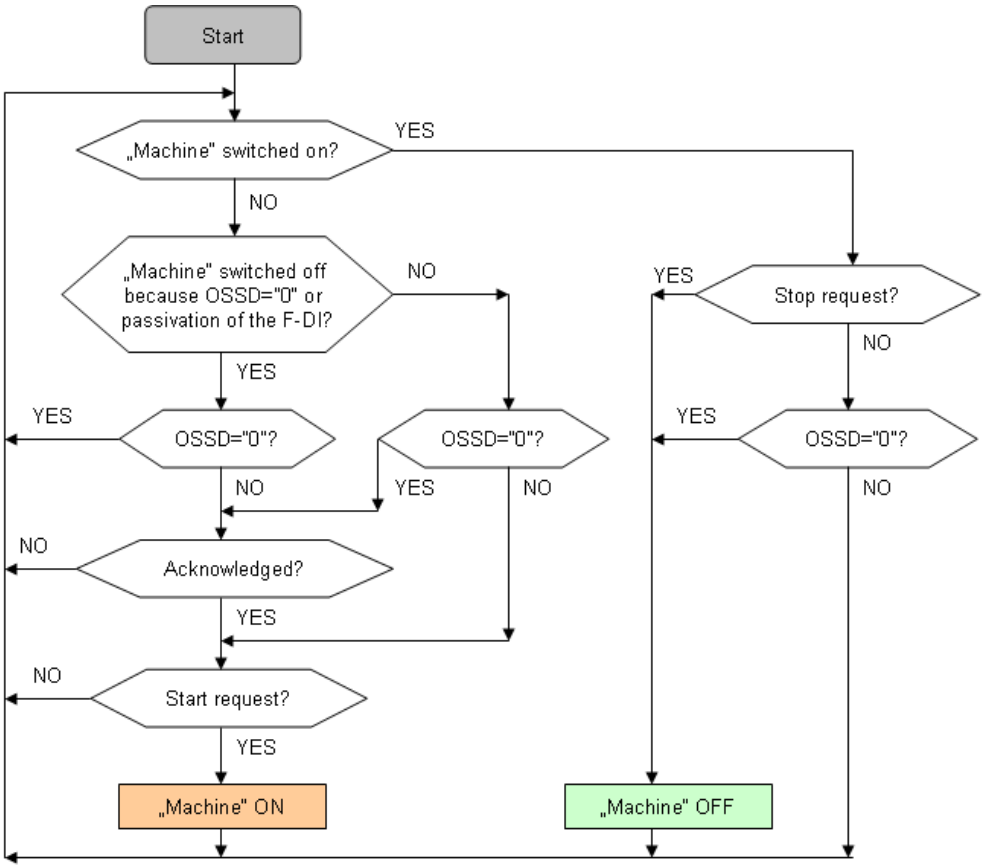
## Flowchart

The flowchart illustrates the function process of the safety functional example.




**NOTICE**

**In order to meet the requirements of category 3 / SIL 2, it is obligatory for certain actuators (e.g. contactor) to read back the process signal to the actuator.**

**Read-back is not implemented in this safety functional example. The actuator is an indicator light simulating a machine. When using different actuators, the feedback circuits have to be integrated and evaluated by the user. Safety functional example 7 provides a detailed description of "Read back".**

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### Time sequence

The following picture illustrates the relations over time. The names of the signals correspond to those in the STEP7 project.

The designations are displayed in the table below.

| Signal | Explanation |
|---|---|
| START | Start command for switching the indicator light (actuator) on. |
| STOP | Stop command for switching the indicator light (actuator) off. |
| ACK | Acknowledgement signal |
| OSSD | Bit read by the fail-safe S7-CPU (F-CPU) from the laser scanner SIMATIC FS600 via PROFIBUS. A signal change from “1“ to “0“ indicates a detection zone violation. |
| ACTUATOR | Fail-safe output with indicator light (actuator) connected to it. |

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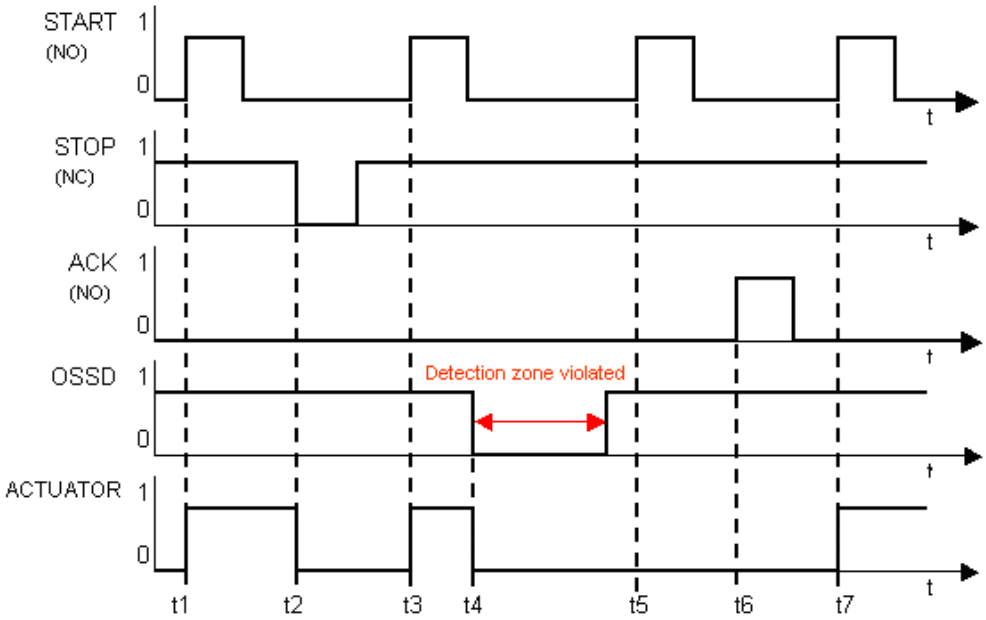
Time sequence of the signals:




**Note** Requirement for the above time sequence is an active zone pair.

Explanation of the above times

| Time | Note / Explanation |
|---|---|
| t1 | Switching the actuator on: Indicator light goes on (ACTUATOR="1"). |
| t2 | Switching the actuator off: Indicator light goes on (ACTUATOR="0"). |
| t3 | Switching the actuator on: Indicator light goes on (ACTUATOR="1"). |
| t4 | The laser scanner SIMATIC FS600 recognizes a violation of the active detection zone (OSSD="0") |
| t5 | A new start request does **not** cause the indicator light to be switched on. It hast to be acknowledged first (see below). |
| t6 | Acknowledgement |
| t7 | The start request now causes the actuator (indicator light) to be switched on. |

**Reaction times**

Use the Excel file available for S7 Distributed Safety V 5.4 to calculate the max. response time of your F system. This file is available on the internet:

http://support.automation.siemens.com/WW/view/en/25412441

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## 2.2 Advantage / Customer benefits

**SIMATIC Safety Integrated**

- Wiring reduced to a minimum due to use of fail-safe S7-CPU and distributed I/O. The more safety functions are implemented, the more useful this advantage is.
- Programming the fail-safe program with STEP7 engineering tools.
- Only one S7-CPU is required, since fail-safe program parts run on a coexistent basis in the S7-CPU
- Use of prefabricated and certified failsafe blocks from the S7 Distributed Safety library (F application blocks).

**Laser scanner SIMATIC FS600**

- Four fully configurable detection zone pairs
- Detection zone switching with any sensors without additional evaluation device
- Monitored radius up to 190°
- Low current draw (approx. 300 mA)
- Simple connection to PROFIBUS-DP
- Comfortable configuration and diagnostics software LS4soft

# 3 Required components

## Hardware components

| Component | Type | MLFB / Order information | No. | Manufacturer |
|---|---|---|---|---|
| Power supply | PS307 5A | 6ES73071EA00-0AA0 | 1 | SIEMENS AG |
| S7-CPU, can be used for safety applications | CPU 315F-2DP | 6ES7315-6FF01-0AB0 | 1 | |
| Micro Memory Card | MMC 512 kBytes | 6ES7953-8LJ11-0AA0 | 1 | |
| Interface module for ET 200S | IM 151 High Feature | 6ES7151-1BA02-0AB0 | 1 | |
| Power module for ET 200S | PM-E DC24..48V AC24..230V | 6ES7138-4CB11-0AB0 | 2 | |
| Electronic module for ET 200S | 2DI HF DC24V | 6ES7131-4BB01-0AB0 | 2 | |
| Electronic module for ET 200S | 4/8 F-DI DC24V | 6ES7138-4FA03-0AB0 | 1 | |
| Electronic module for ET 200S | 4 F-DO DC24V/2A | 6ES7138-4FB02-0AB0 | 1 | |
| Terminal module for ET 200S | TM-P15S23-A0 | 6ES7193-4CD20-0AA0 | 2 | |
| Terminal module for ET 200S | TM-E15S24-A1 | 6ES7193-4CA20-0AA0 | 2 | |
| Terminal module for ET 200S | TM-E30C46-A1 | 6ES7193-4CF50-0AA0 | 2 | |
| Mounting rail | 19.00 in | 6ES7390-1AE80-0AA0 | 1 | |
| Standard mounting rail | 35 mm, length:483 mm | 6ES5710-8MA11 | 1 | |
| Push button | Green, 1NO | 3SB3801-0DA3 | 3 | |
| Push button | Red, 1NC | 3SB3801-0DB3 | 1 | |
| Position switch | Overtravel plunger, 1S+1Ö | 3SE5232-0HC05 | 2 | |
| Indicator light with lamp | Yellow | 3SB3217-6AA30 | 1 | |
| Laser scanner SIMATIC FS600 | for PROFIBUS | 3SF7834-6PB00 | 1 | |
| Optical PC adapter cable | | 3RG7838-1DC | 1 | |
| PROFIBUS M12 connecting plug | Pin insert (5 ea) | 6GK1905-0EA00 | 1 | |
| PROFIBUS M12 connecting plug | Connector insert (5 ea) | 6GK1905-0EB00 | 1 | |
| PROFIBUS M12 connecting plug | (5 ea) | 6GK1905-0EC00 | 1 | |

**Note** The functionality was tested using above hardware components. Similar products not included in the above list can also be used. Please note that in this case changes in the sample code (e.g. different addresses) may become necessary.

**Note** The HF electronic modules can be replaced by standard modules. One 4DI electronic module can be used instead of two 2DI electronic modules.

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### Configuration software/tools

| Component | Type | MLFB / Order information | No. | Manufacturer |
|---|---|---|---|---|
| SIMATIC STEP 7 | V5.4 + SP1 | 6ES7810-4CC07-0YA5 | 1 | SIEMENS AG |
| SIMATIC Distributed Safety | V5.4 + SP3 | 6ES7833-1FC01-0YA5 | 1 | |
| LS4soft | V1.12 | Delivered with laser scanner SIMATIC FS600 | 1 | |

# 4 Setup and Wiring

In order to set up and wire the safety functional example, it is absolutely necessary to consider the following note:

**NOTICE**

**In order to meet the requirements of category 3 / SIL 2, it is obligatory for certain actuators (e.g. contactor) to read back the process signal to the actuator.**

**Read-back is not implemented in this safety functional example. The actuator is an indicator light simulating a machine. When using different actuators, the feedback circuits have to be integrated and evaluated by the user. Safety functional example 7 provides a detailed description of "Read back".**

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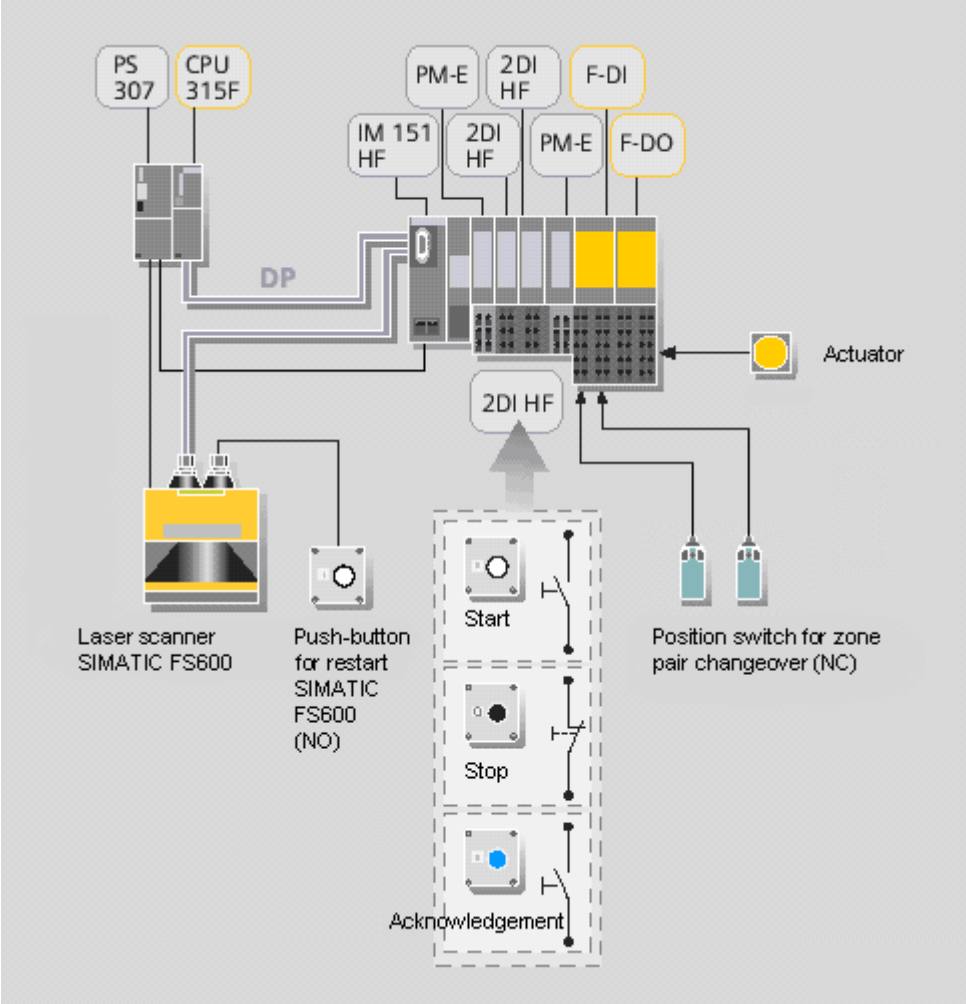
## 4.1 Overview of the hardware configuration

The laser scanner SIMATIC FS600 is operated as DP slave on the PROFIBUS DP (with PROFIsafe profile). An F-CPU is used as DP master.

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## 4.2 Wiring of hardware components

Requirements: The power supply is supplied with 230V AC.

First check the addresses set at the hardware components listed below:

| Hardware component | Address to be set | Explanation/notes |
|---|---|---|
| IM 151 HF | 6 (PROFIBUS address) | Can be changed |
| laser scanner SIMATIC FS600 | 4 (PROFIBUS address) | Default setting, can be changed |
| F-DI | Switch position: 1111111110 | The PROFIsafe addresses are automatically assigned when configuring the fail-safe modules in STEP 7.<br>The PROFIsafe addresses 1 to 1022 are permissible. Please make sure that the setting at the address switch (DIL switch) on the side of the module corresponds to the PROFIsafe address in the hardware configuration of STEP7. |
| F-DO | Switch position: 1111111101 | |

**Note** The laser scanner SIMATIC FS600 is not illustrated in the picture below. Its connections will be discussed separately later on.

**Note** The DP interface of the CPU 315F-2DP must be connected to the DP interface of the IM 151 HF and to the laser scanner SIMATIC FS600.

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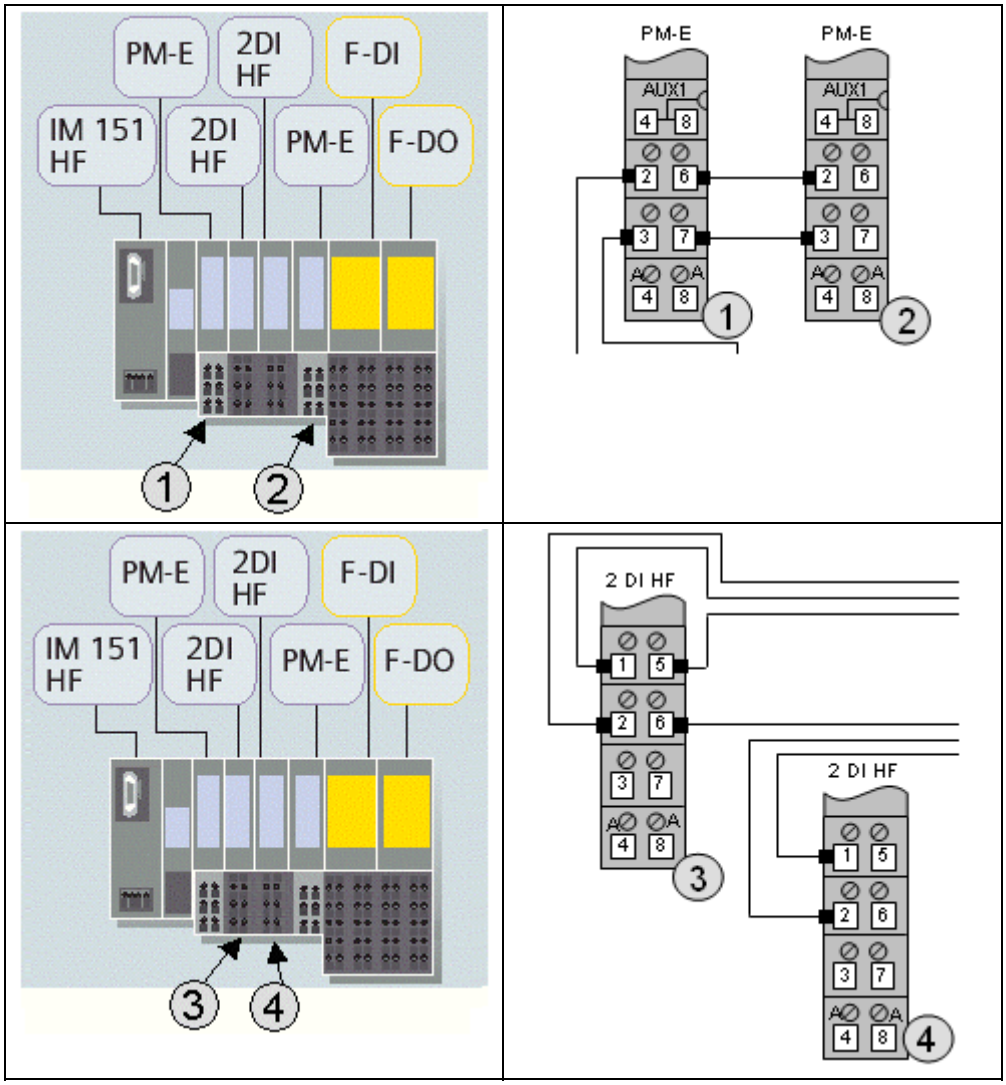
**Note**

The wiring of the hardware is illustrated below. In the following table, the hardware components occurring several times are numbered. This ensures that they can be clearly assigned in the subsequent wiring diagram.

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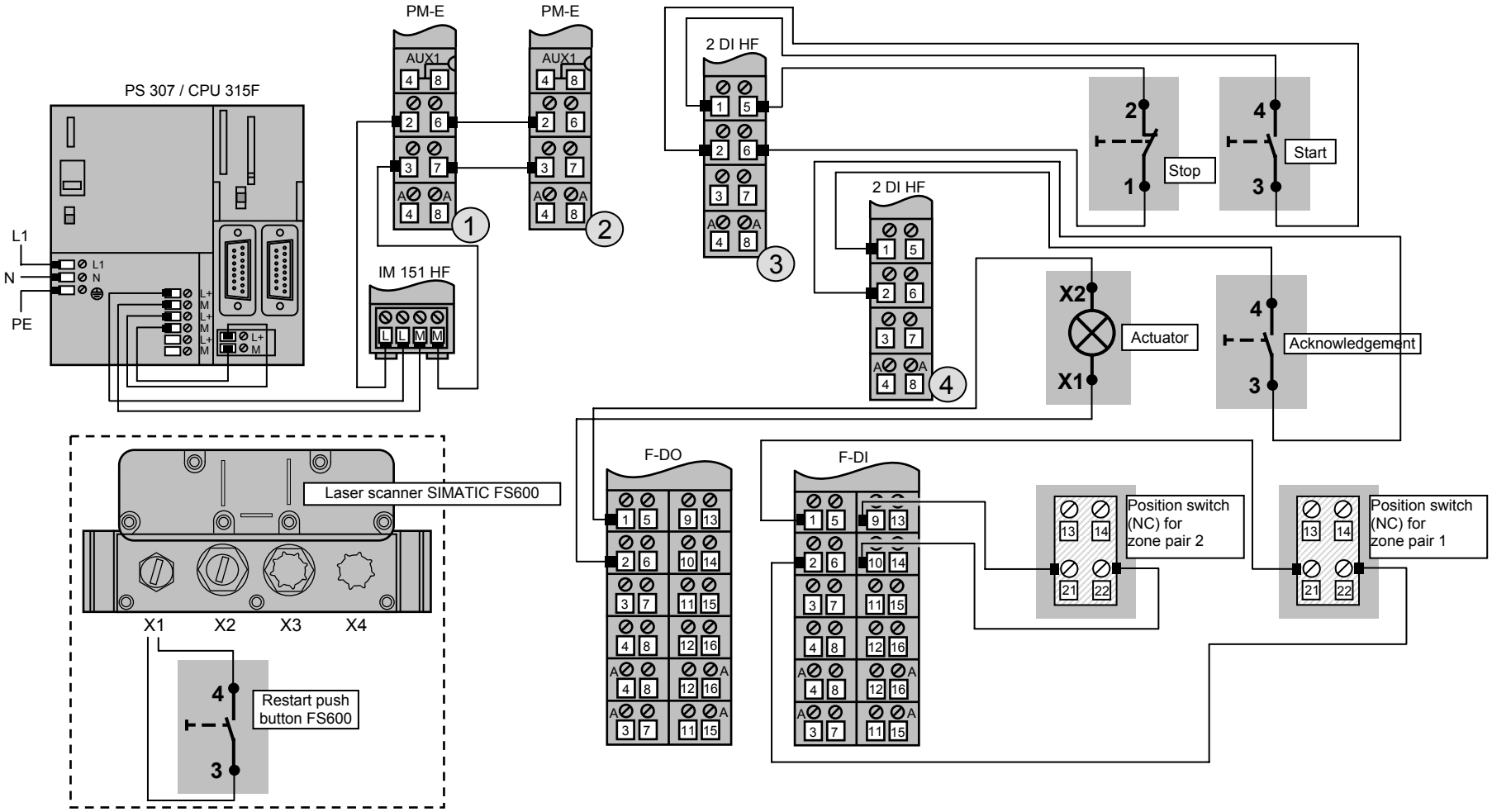
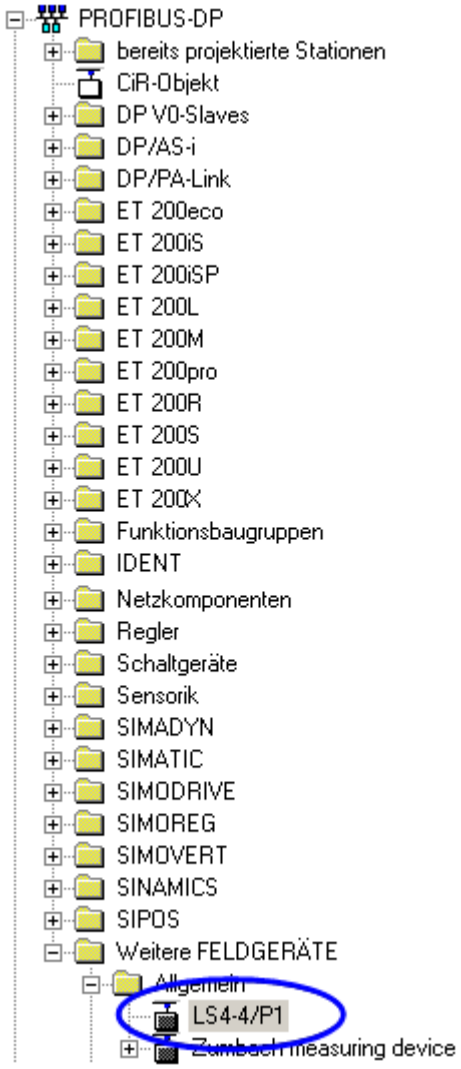


## Connecting the laser scanner SIMATIC FS600 to PROFIBUS

In order to integrate the laser scanner SIMATIC FS600 into the PROFIBUS network, you need the device master file (GSD) of the SIMATIC FS600 laser scanner. This file comes with the laser scanner SIMATIC FS600. To install the file into the hardware configuration of STEP7, proceed as follows:

- Menu: Options -> Install new GSD

Subsequently, the laser scanner SIMATIC FS600 is available in the hardware catalog (within the hardware configuration of STEP 7):

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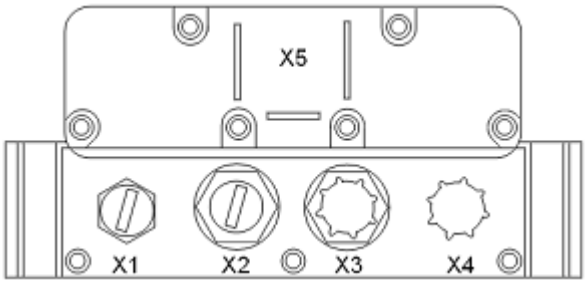
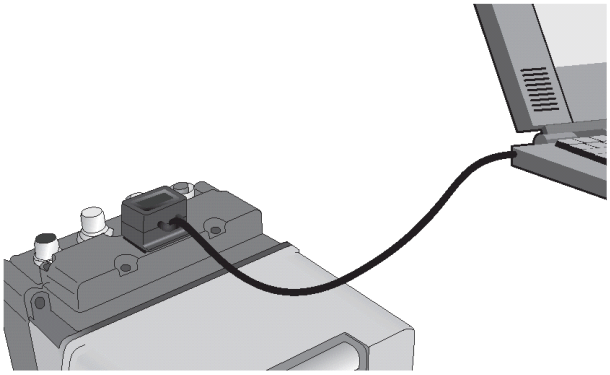
The laser scanner SIMATIC FS600 has five male/female connectors (X1 to X5).




Connect these male/female connectors as follows:

| Male/female connector | Function | Note / Explanation |
|---|---|---|
| X1 | Restart button | Connect a push button (NO) here. (This is considered in chapter 3 in the “Hardware components” table.)<br>The push button has two functions:<br>• Unlocking the internal start or restart inhibit of the laser scanner SIMATIC FS600, if activated. This function is **not** activated in the safety functional example. But a restart inhibit is implemented in the safety program.<br>• Error acknowledgement, if the laser scanner SIMATIC FS600 is in failure mode. |
| X2 | PROFIBUS output | If the laser scanner SIMATIC FS600 is the last device on the PROFIBUS, a standards compliant terminating resistor must be connected. |
| X3 | PROFIBUS input | --- |
| X4 | Power supply | Pin 1: +24V DC<br>Pin 3: 0V DC |
| X5 | Optical PC interface (also referred to as PC adapter) | Connected to the COM interface of the PG/PC on which the LS4soft configuration and diagnostics software has been installed.<br>  |

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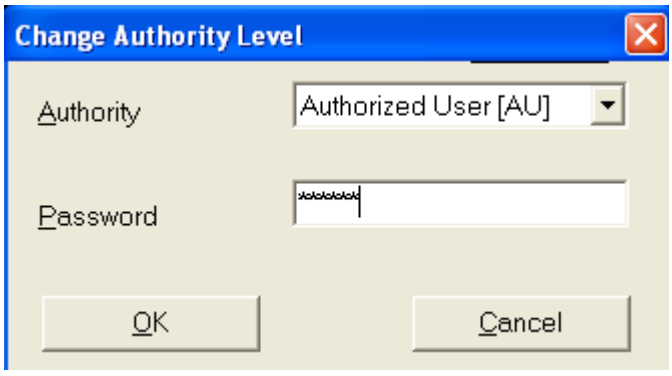
**Note** The cable outlet of the PC adapter at the laser scanner SIMATIC FS600 must face towards the direction of the detection zone. The PC adapter should only be connected in the installation phase or for control purposes.

## 4.3 LS4soft configuration and diagnostics software

The example below shows how to load the following file containing the parameter set into the laser scanner SIMATIC FS600.

- as_fe_i_010_v10_code_plscanner.ls

This file is available as download to the safety functional example (as the associated STEP 7 project)

| No. | Action | Note |
|---|---|---|
| 1 | Install the LS4soft configuration and diagnostics software on your PG/PC. | |
| 2 | Switch the laser scanner SIMATIC FS600 on. | |
| 3 | Start LS4soft. | |
| 4 | Connect the COM interface of your PG/PC with the laser scanner SIMATIC FS600 using the PC adapter. | The configuration data currently located on the laser scanner SIMATIC FS600 are being loaded. |
| 5 | Log on as “Authorized User“ and enter the required password. Ls4sig   | A query that no individual password has been specified appears.<br>Confirm the dialog box. |
| 6 | Wait until the laser scanner SIMATIC FS600 has determined all status information. | The “Determining status information from scanner” window closes automatically. |
| 7 | Click “Close” in the “Scanner status information” window. | |

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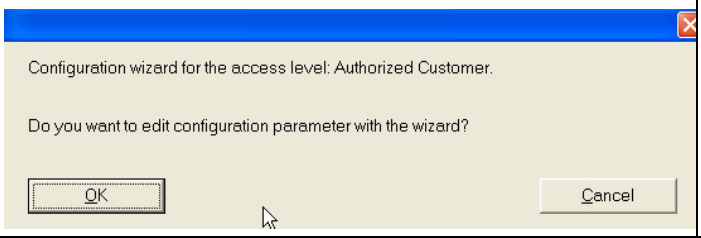
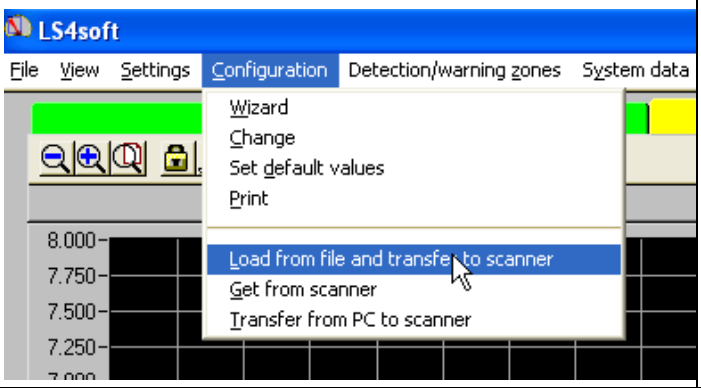
| No. | Action | Note |
|---|---|---|
| 8 | Click “Cancel”.<br>  | You do not generate a new configuration but use the file as_fe_i_010_v10_code_plscanner.ls. |
| 9 | Verify whether the “Display measurement diagram” tab is active. | The currently active zone pairs and the associated contours appear. |
| 10 | Click the “Configuration” tab and click „Load from file and transfer to scanner“ in the menu.<br>  | |
| 11 | Now search for the file as_fe_i_010_v10_code_plscanner.ls.<br>and follow the further instructions. | |

**Note** Ensure the COM interface is set correctly. The COM interface settings are available in the menu:

Settings ->PC configuration -> Interface.

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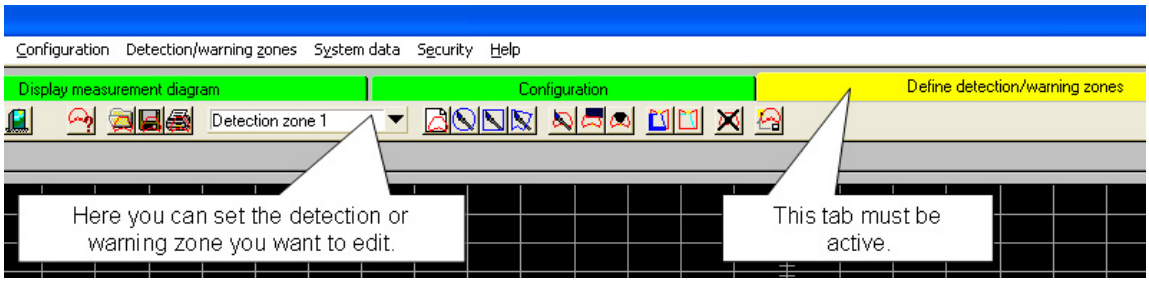
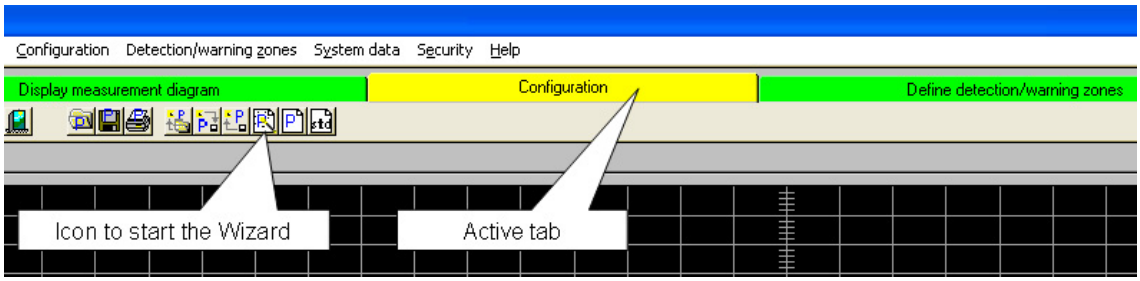
### Changing detection and warning zones

If you wish to change detection and warning zones, click the “Define detection/warning zones“ tab. Then set the detection or warning zone you want to edit.

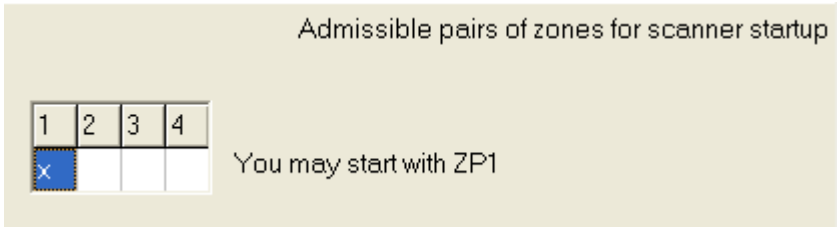



### Working with the wizard

A useful wizard is available for “Authorized Users” to parameterize the laser scanner SIMATIC FS600. The next picture shows how to start the wizard.




The wizard allows you to specify for example which zone pairs to enable when starting the laser scanner SIMATIC FS600. In the safety functional example, this is zone pair1 (detection zone 1 and warning zone 1).

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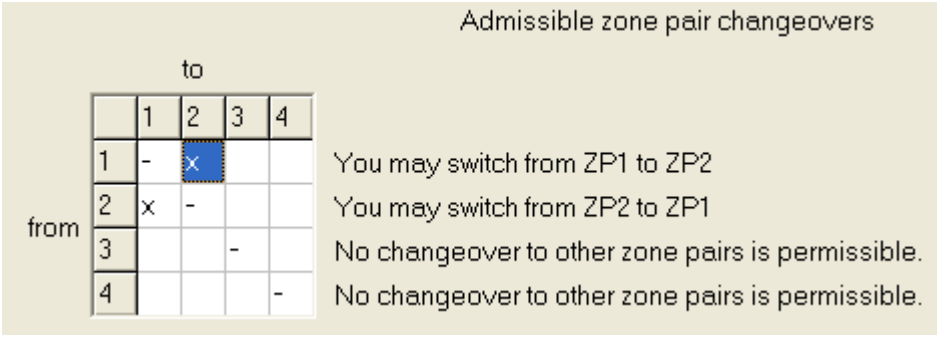
The wizard can also be used to specify which zone pairs can be changed over. In the safety functional example, it is allowed to switch from zone pair 1 to 2 and from zone pair 2 to 1.


Admissible zone pair changeovers
to
from
1 2 3 4
1 - x
2 x -
3 -
4 -
You may switch from ZP1 to ZP2
You may switch from ZP2 to ZP1
No changeover to other zone pairs is permissible.
No changeover to other zone pairs is permissible.

## 4.4 Function test

The inputs and outputs used can be checked with regard to their functionality if the following conditions are met:

- the hardware components are wired
- the STEP 7 project was loaded into the S7-CPU
- the following file was transmitted to the laser scanner SIMATIC FS600: as_fe_i_010_v10_code_plscanner.ls.

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**Inputs/outputs used**

| No. | HW component | Address | Symbol | Signal (default value) | Note |
|---|---|---|---|---|---|
| 1 | Push button (NO) | E 0.0 | START | “0” | Switches the indicator light on |
| 2 | Push button (NC) | E 0.1 | STOP | “1” | Switches the indicator light off |
| 3 | Push button (NO) | E 1.0 | ACK | “0“ | Acknowledgement |
| 4 | Position switch 1 (NC) | E 2.0 | SEN_FIELD1 | “1“ | Defining which zone pair is active. |
| 5 | Position switch 2 (NC) | E 2.4 | SEN_FIELD2 | “1“ | |
| 6 | Actuator (indicator light) | A 8.0 | ACTUATOR | “0” | Simulates a hazardous machine. “0“ signal: "Machine" is switched off |

### Testing inputs and outputs

Prerequisites:

- The inputs and outputs have the default values specified under “Inputs/outputs used”.
- No objects are currently in the detection zone of the laser scanner SIMATIC FS600.

| No. | Action | Response | Note |
|---|---|---|---|
| | | A 8.0 | |
| 1 | Hold position switch 1 on “0” signal | “0“ | Activating zone pair 1 (detection zone 1 and warning zone 1) |
| 2 | Hold position switch 2 on “1” signal | “0“ | |
| 3 | Press the push button ACK and release it | “0“ | Acknowledgement necessary at initial start. |
| 4 | Press the START push button and release it | “1“ | Start of the “machine” |
| 5 | Press the STOP push button and release it | “0“ | Stop of the “machine” |
| 6 | Press the START push button and release it | “1“ | No acknowledgement required for start |
| 7 | Place an object into the detection zone of the laser scanner SIMATIC FS600. | “0“ | Violation of the detection zone |
| 8 | Remove the object from the detection zone of the laser scanner SIMATIC FS600. | “0“ | --- |
| 9 | Press the START push button and release it | “0“ | Acknowledgement necessary prior to the start. |
| 10 | Press the push button ACK and release it | “0“ | Acknowledgement |
| 11 | Press the START push button and release it | “1“ | The “machine” can be started again. |

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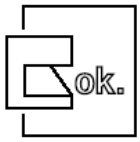
### Testing the LEDs at the laser scanner SIMATIC FS600

The laser scanner SIMATIC FS600 indicates its current status via five LEDs:

| LED | Color | Function / Meaning | Pictogram |
|---|---|---|---|
| 1 | Green | Sensor function is active, active detection zone is free | |
| 2 | Yellow | Warning zone occupied | |
| 3 | Red | OSSD outputs switched off | |
| 4 | Green | OSSD outputs switched on |   |
| 5 | Yellow | Permanent light:<br>Restarting lockout<br><br>Slowly blinking (1):<br>Warning message (ca. 0.25 Hz)<br><br>Blinking fast (((1))):<br>Failure message (ca. 4 Hz) | |

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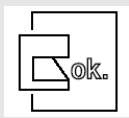
To test the laser scanner SIMATIC FS600, carry out the following actions:

| No. | Action | Response | | | | |
|---|---|---|---|---|---|---|
| | | | | |  | |
| 1 | Make sure that no objects are located in either the warning zone, or the detection zone | ON | OFF | OFF | ON | OFF |
| 2 | Place an object into the warning zone of the laser scanner SIMATIC FS600. | ON | ON | OFF | ON | OFF |
| 3 | Place an object into the detection zone of the laser scanner SIMATIC FS600. | OFF | ON | ON | OFF | OFF |

**Note**

To reset a fault indication of the laser scanner SIMATIC FS600, the following conditions must be satisfied:

- the fault has been eliminated
- “1” signal is received by the SIMATIC FS600 via the restart button.

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## 4.5 Important hardware component settings

The STEP 7 project delivered with this safety functional example contains the hardware configuration and the sample code.

Below, several important settings from the hardware configuration of STEP 7 are shown to give you an overview. It is basically possible to change these settings (e.g. due to individual requirements), but please consider the following note:

**NOTICE** **The settings shown below contribute to meeting the requirements of category 3 / PL d / SIL 2. Changes at the settings may cause loss of the safety function.**

If you make changes to the hardware configuration of STEP 7 (e.g. add an additional module), the sample code of the delivered STEP 7 project must be adapted accordingly.

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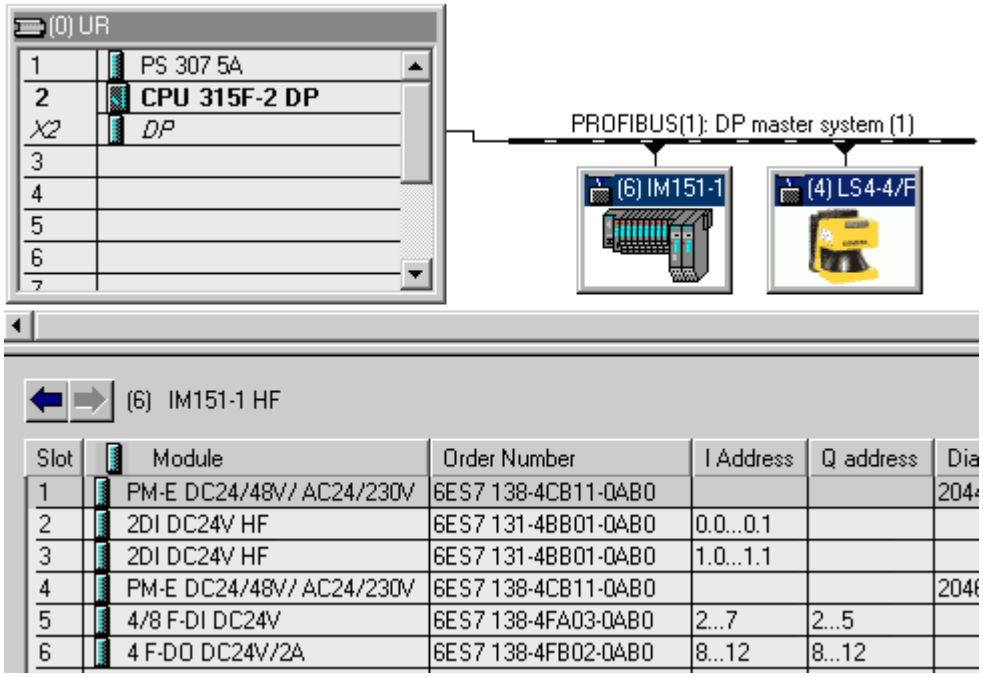
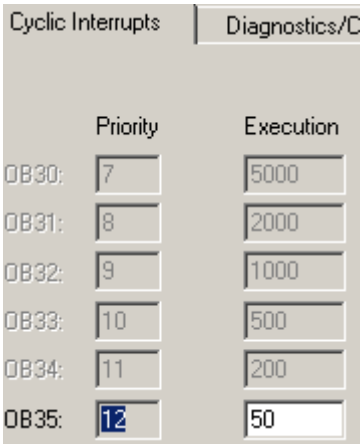
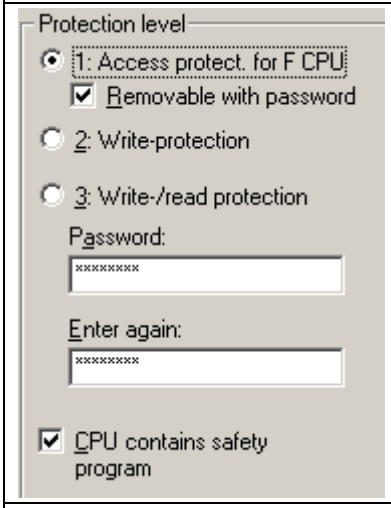
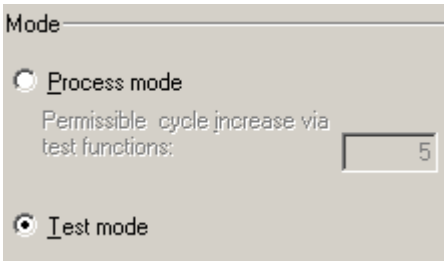
### Overview picture


(0) UR
1 PS 307 5A
2 CPU 315F-2 DP
X2 DP
3
4
5
6
PROFIBUS(1): DP master system (1)
(6) IM151-1
(4) LS4-4/F
(6) IM151-1 HF
Slot Module Order Number I Address Q address
1 PM-E DC24/48V/ AC24/230V 6ES7 138-4CB11-0AB0
2 2DI DC24V HF 6ES7 131-4BB01-0AB0 0.0...0.1
3 2DI DC24V HF 6ES7 131-4BB01-0AB0 1.0...1.1
4 PM-E DC24/48V/ AC24/230V 6ES7 138-4CB11-0AB0
5 4/8 F-DI DC24V 6ES7 138-4FA03-0AB0 2...7 2...5
6 4 F-DO DC24V/2A 6ES7 138-4FB02-0AB0 8...12 8...12

The PROFIBUS address at IM 151 HF is set using DIP switches.

### Settings of the CPU 315F-2DP

The settings are displayed after double-clicking “CPU 315F-2 DP” (see “Overview picture”).

| Screenshot | Note |
|---|---|
|  | OB35 is set to 50 ms (default value = 100 ms)<br><br>You must make sure that the F monitoring time is greater than the call time of OB 35 (see "Settings of the failsafe DI" or "Settings of the failsafe DO"). |
|  | A password has to be created in order to be able to set the parameter “CPU contains safety program”. It is only in this case that all required F blocks for safe operation of the F modules are generated during compiling the hardware configuration of STEP 7.<br><br>Password used here: siemens |
|  | Set mode: "Test mode"<br>During **Process Mode**, the test functions such as program status or monitor/modify variable are restricted in such a way that the set permitted increase in scan cycle time is not exceeded. Testing with stop-points and gradual program execution cannot be performed.<br>During **Test Mode**, all test functions can be used without restrictions via PG/PC which can also cause larger extensions of the cycle time.<br>Important: During test mode of the S7-CPU, you have to make sure that the S7-CPU or the process can “stand” large increases in cycle time. |

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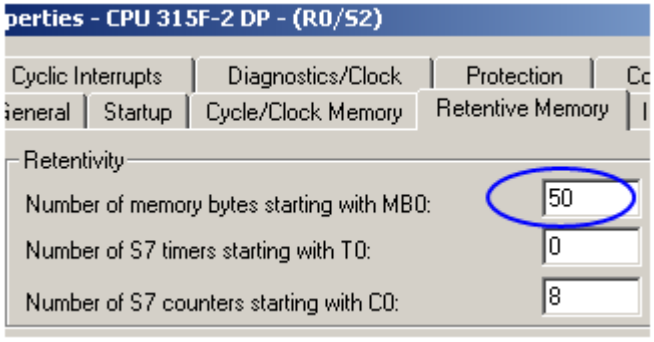
| Screenshot | Note |
|---|---|
|  | The laser scanner SIMATIC FS600 comes with the “FB LS4” function block. The “FB LS4” is **not** used in the safety functional example.<br>If you want to use the “FB LS4“ for adjusting the sample code to your requirements, you must ensure to reserve a retentive memory area of at least 34 bytes. |

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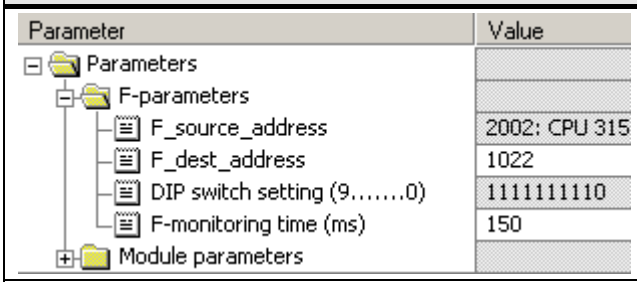
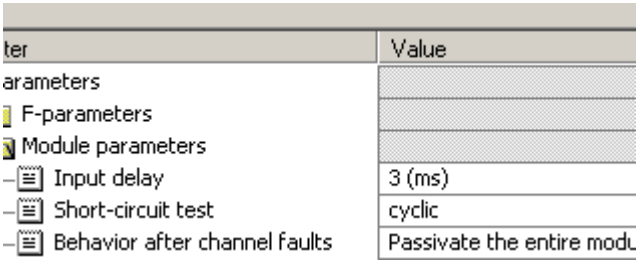
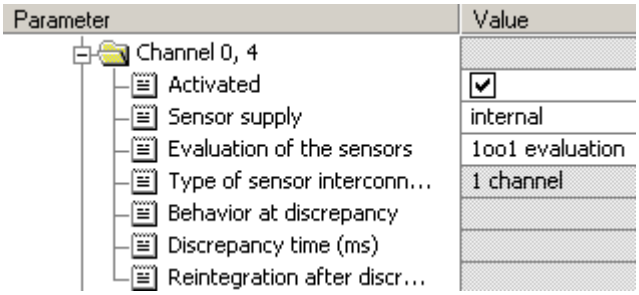
### Settings of the failsafe DI (F-DI)

The settings are displayed after double-clicking “4/8 F-DI DC24V” (see “Overview picture”).

| Screenshot | Note |
|---|---|
|  | **Parameters / F parameters:**<br>DIP switch setting (9…0)<br>This value has to be set on the F module (F-DI).<br>F-monitoring time (ms)<br>The F-monitoring time must be larger than the call time of OB35. |
|  | **Parameters / Module parameters:**<br>Category 3 / PL d / SIL 2 is reached by carrying out a cross-circuit detection. The cyclic short-circuit test and the sensor supply must be activated via the F module.<br>Short-circuit test<br>cyclic short-circuit test is activated (cross-circuit detection).<br>Behavior after channel faults<br>The entire F module is passivated in the event of a channel fault. |
|  | **Parameters / Module parameters:**<br>Assignment of channels:<br>Channel 0, 4<br>Channel 0 Position switch 1<br>channel 4: Position switch 2<br>The sensors define which zone pair must be active.<br><br>Parameterization of the channels<br>Activated<br>Used channels are activated, unused channels are deactivated.<br>Sensor supply<br>The internal sensor voltage is activated so that the short-circuit test can be carried out.<br>Evaluation of the sensors<br>Both position switches connected as single channel. |

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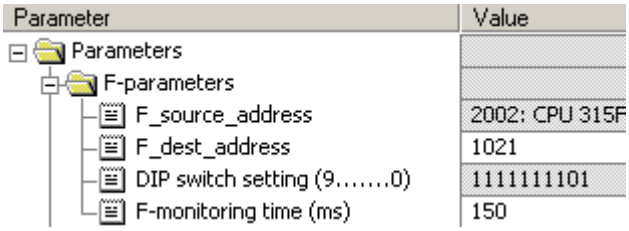
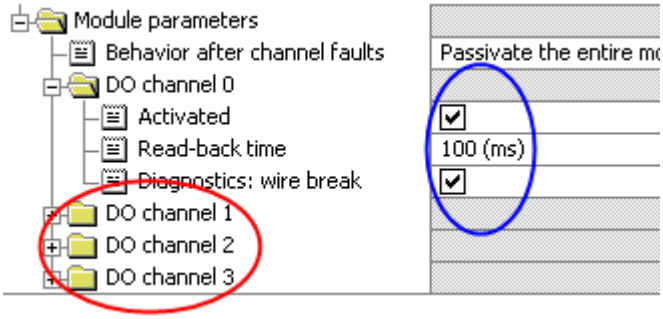
### Settings of the fail-safe DO (F-DO)

The settings are displayed after double-clicking “4 F-DO DC24V/2A” (Overview picture).

| Screenshot | Note |
|---|---|
|  | **Parameters / F parameters:**<br>DIP switch setting (9…0)<br>This value has to be set on the F module (F-DO).<br>F-monitoring time (ms)<br>The F-monitoring time must be larger than the call time of OB35. |
|  | **Parameters / Module parameters:**<br>Assignment of channels:<br>DO channel 0:<br>Channel 0 switches the indicator light<br><br>Parameterization of the channels:<br>Behavior after channel faults<br>The entire F module is passivated in the event of a channel fault.<br>Activated<br>Used channels are activated, unused channels are deactivated.<br>Read-back time<br>The read-back time defines the duration of the switch-off procedure for the channel. If the channel switches high capacity loads the read-back time should be set sufficiently. We recommend setting the read back time as small as possible, however large enough so that the channel does not become passive. |

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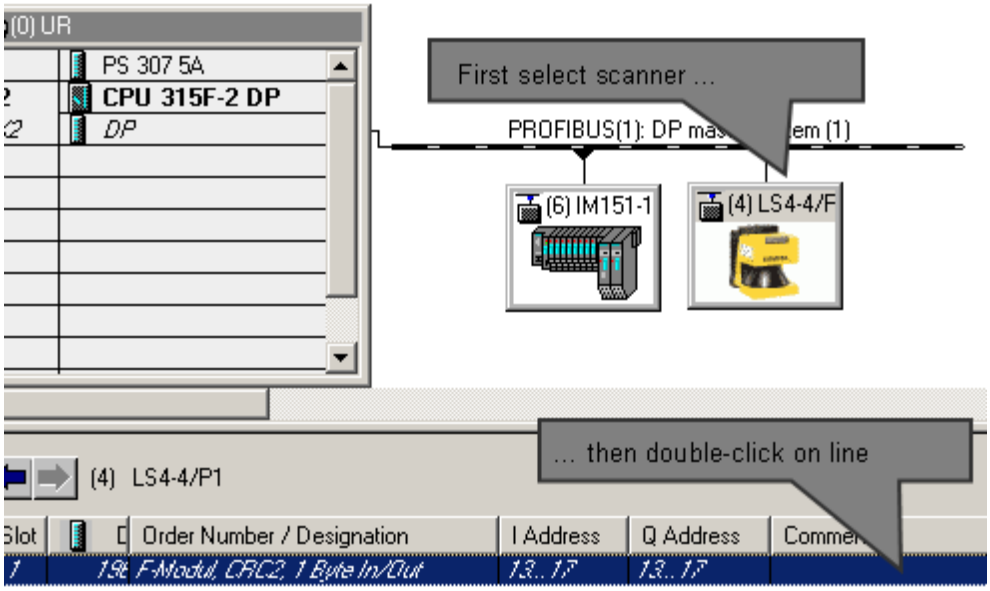
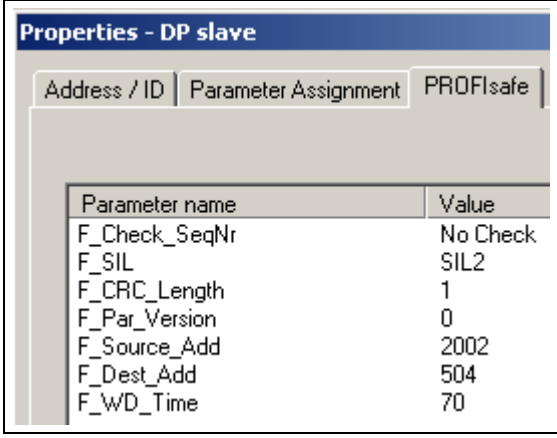
### Settings of the laser scanner SIMATIC FS600

Select the laser scanner SIMATIC FS600 and double-click the line that appears:




Then click the PROFIsafe tab.

| Screenshot | Note |
|---|---|
|  | F_Dest_Add<br>This value derives from the PROPIBUS address (here: 4) plus 500.<br><br>F_WD_Time<br>The default value of 10 ms is usually too small.<br>A valid, current safety message must be received from the F-CPU during the monitoring time. Or the DP slave will go into safe mode. |



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# 5 Basic Performance Data

### Load memory and main memory

| | Total | Portion of S7 standard blocks | Portion of F blocks |
|---|---|---|---|
| Load Memory | 93.8 Kbytes | 47.7 Kbytes | 46.1 Kbytes |
| Main Memory | 76.3 Kbytes | 43.9 Kbytes | 32.4 Kbytes |

### Cycle time

| | Time | Note |
|---|---|---|
| Typical total cycle time (standard program and safety program) | Approx. 3 ms | Measurement in the S7-CPU ("Module information CPU" / "Cycle time") |
| Maximum runtime safety program | 13 ms | Calculation using an Excel file available for S7 Distributed Safety Chapter 2 tells you where on the internet you can find the table. |

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# 6 Sample Code

## 6.1 Download

### Preliminary remark

The STEP 7 project delivered with this safety functional example contains the hardware configuration and the sample code. The sample code is described in the following.

The sample code is always assigned to the components used in the safety functional example and implements the required functionality. Problems not dealt with in this document are to be realized by the user; the sample code may serve as a basis.

The sample code provides measures for fault detection (diagnostics). The user has to evaluate this information and the fault must be responded to (second shut-down method, ...).

**Note** A connection between the MPI interface of your PG/PC and the MPI interface of the CPU 315F-2DP (MPI cable) is required to download the STEP7 project into the CPU 315F-2DP.

### Password

In all cases, the password used for the safety-relevant part of the sample code is: siemens

### Use of the STEP7 project

The STEP 7 project shows how a laser scanner SIMATIC FS600 is used with SIMATIC Safety Integrated.

### Functionality of the STEP 7 project

The following functions are implemented with the STEP 7 project:

- Operational start and stop of a “machine”
- If the detection zone is violated, the fail-safe S7-CPU (F-CPU) will switch off an actuator (indicator light).
- Changeover between two zone pairs:
  Zone pair 1 (SF1, WF1) and zone pair 2 (SF2, WF2)

An expansion by three or four zone pairs is prepared in the sample code. A violation of warning zones is not evaluated in the STEP7 sample code.

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### Downloading the STEP 7 project

On the html page of the safety functional example, you will find the following file containing the STEP 7 project as download:

- 21330889_as_fe_i_010_v20_code_clscanner.zip

Save this file to any directory on your PC / PG. Start STEP 7 and extract the file into any directory. To load the STEP 7 project into the S7-CPU, proceed as follows:

- First load the hardware configuration into the S7-CPU
- Switch to the SIMATIC Manager.
- Select the S7-CPU.
- Go to the "Options" menu and select: "Edit safety program"
- Click the "Download" button
  to load the sample code in to the S7-CPU.

### Downloading the parameters for the laser scanner SIMATIC FS600

On the html page of the safety functional example, you will find the following file containing the parameters for the SIMATIC FS600 laser scanner as download:

- as_fe_i_010_v10_code_plscanner.ls.

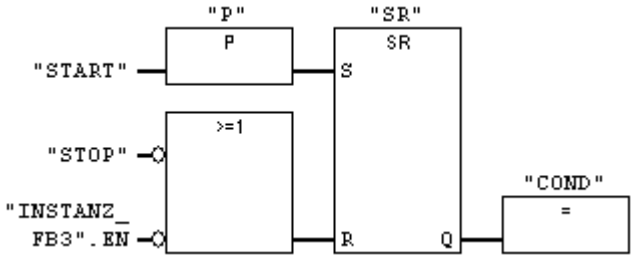
Load this file into the laser scanner SIMATIC FS600. Further information is given in chapter 4.3.

## 6.2 Program execution standard program

**OB1**

**Network 1**

Network 1 evaluates the conditions for an operational start or stop of the “machine” (indicator light).




| Parameter | Explanation |
|---|---|
| START | Push button (NO) for the start request. |
| STOP | Push button (NC) for the stop request |
| INSTANZ_FB3.EN | The “INSTANZ_FB3”.EN bit includes the status of an SR flip-flop in the safety program (FB3, NW1) and in this case prevents that the “machine” (indicator light) can be started by an acknowledgement generated in the safety program.<br>As long as “INSTANZ_FB3”.EN=“0”, COND= “0” remains true because the reset function has priority in this flip-flop type. |
| COND | Information for the safety program:<br>Start or stop of the “machine” (actuator or indicator light) |

The "COND" memory bit is read as "COND1" memory bit in the safety program. The allocation occurs in the cyclic interrupt OB35 for the following reason:

If you want to read data from the standard program (memory bits or PII of standard I/O) in the safety program (here: COND), which can be changed by the standard program or an operator control and monitoring system during the runtime of an F run-time group, it is required to use separate memory bits (here: COND1). Data from the standard program have to be written to these memory bits immediately before calling the F run-time group. You are allowed to access these memory bits only in the safety program. This is implemented in this way in the safety functional example.

**Note** If the above section is not observed, the F-CPU may go to STOP mode.

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**Network 2**

In OB1 the “Proxy-Enable“ bit (Bit 6 of the cyclic output data) is permanently supplied with the value “0“.

**Network 3**

The laser scanner SIMATIC FS600 can be parameterized automatically when it is replaced. This is prepared in network 3 by calling “FB LS4”. But the automatic parameter configuration is not effective since the Proxy-Enable bit permanently has the value “0”.

To use the automatic parameter configuration, you must set the Proxy-Enable bit permanently to the value “1” before calling the “FB LS4”.

## 6.3 Program execution safety program

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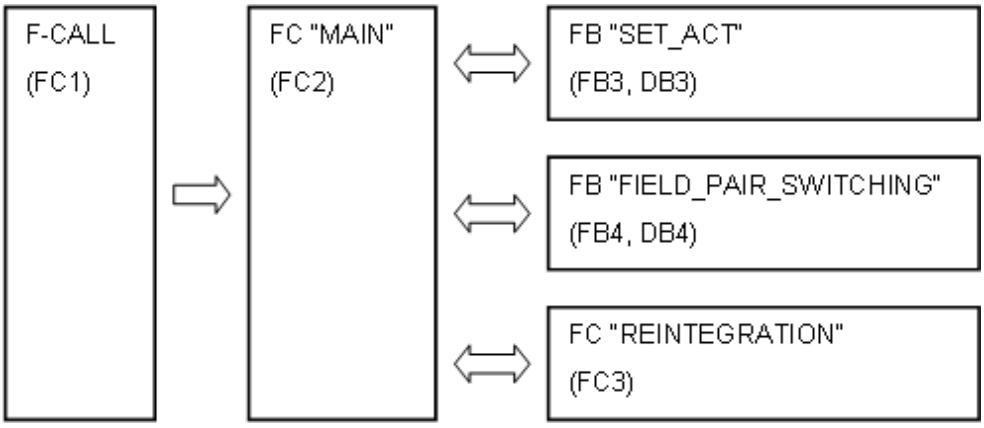
**Structure**

The safety program has the following structure:




**F-CALL (FC1)**

F-CALL (FC1) is the F runtime group and is called from the cyclic interrupt OB (OB35).

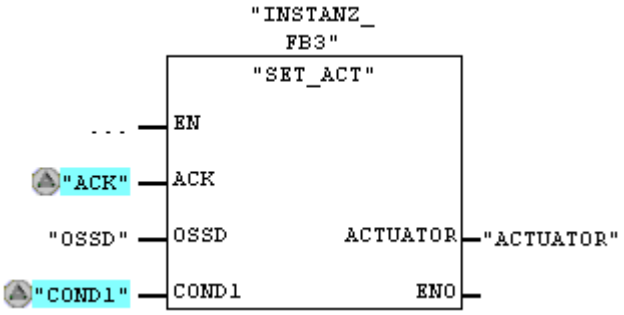
F-CALL (FC1) calls the F program block (here: FC2).

**FC FMAIN (FC2)**

For modularity reasons of the application program, all further fail-safe blocks are called from here.

**Network 1**

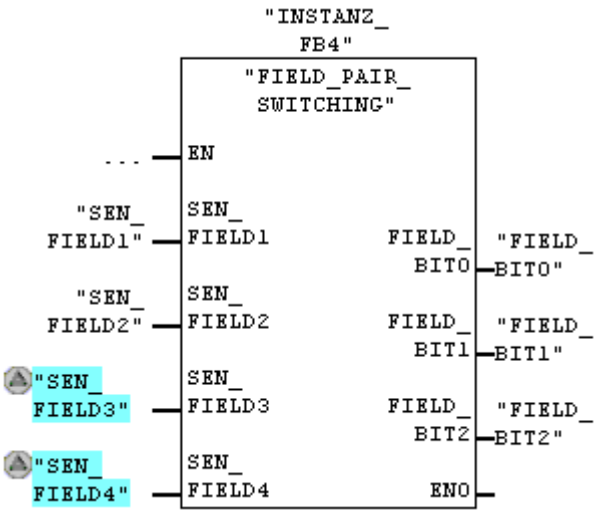
FB SET_ACT (FB3, DB3) is called here:




| Parameter | Explanation |
|---|---|
| ACK | Acknowledgement signal |
| OSSD | Safety-relevant output of the laser scanner SIMATIC FS600 |
| COND1 | Start condition, defined in OB1. |
| ACTUATOR | Indicator light |

**Network 2**

FB FIELD_PAIR_SWITCHING (FB4, DB4) is called here:




Based on the input parameters SEN_FIELD1 and SEN_FIELD2 it is determined which zone pair is active.

The input parameters SEN_FIELD3 and SEN_FIELD4 are not used in the safety functional example.

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The following table describes the parameters.

| Parameter | Explanation |
|---|---|
| SEN_FIELD1 | Position switch 1 (NC)<br>“1“ signal: Switch not applied. |
| SEN_FIELD2 | Position switch 2 (NC)<br>“1“ signal: Switch not applied. |
| SEN_FIELD3 | Memory bit as dummy |
| SEN_FIELD4 | Memory bit as dummy |
| FIELD_BIT0 | Number of the detection zone<br>(Bit 0, 1 and 2 of the cyclic output data) |
| FIELD_BIT1 | |
| FIELD_BIT2 | |

**Network 3**

Here the FC REINTEGRATION (FC3) is called. FC3 is described further below.

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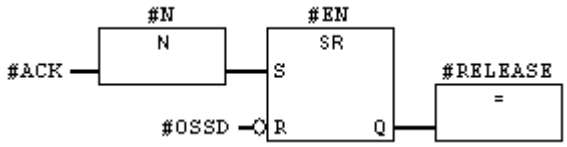
## FB SET_ACT (FB3, DB3)

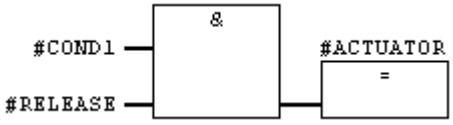
**Network 1**




The status of the SR flip-flop (#EN) is evaluated in OB1 as a condition for a start.

In case of a detection zone violation, OSSD becomes “0“ and resets the SR flip-flop (reset has the priority with this flip-flop bit). As a result, #RELEASE (used in network 2) takes on the value “0”.

**Network 2**




The actuator (indicator light) is only switched on if both conditions are satisfied.

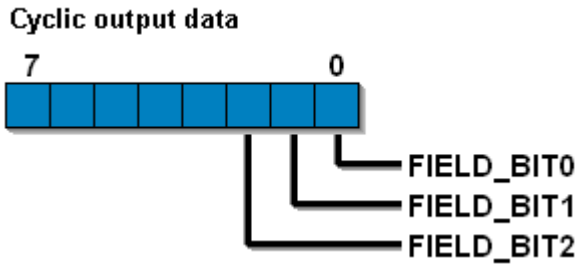
- start condition fulfilled (COND1=”1”, see OB1)
- release was given (RELEASE=”1”, see previous network 1)

## FB FIELD_PAIR_SWITCHING (FB4, DB4)

The following table describes the parameters.

| Parameter | Explanation |
|---|---|
| SEN_FIELD1 | Position switch 1 (NC) |
| SEN_FIELD2 | Position switch 2 (NC) |
| SEN_FIELD3 | Memory bit as dummy |
| SEN_FIELD4 | Memory bit as dummy |
| FIELD_BIT0 | Number of the detection zone (Bit 0, bit 1 and bit 2 of the cyclic output data) |
| FIELD_BIT1 | |
| FIELD_BIT2 | |

A maximum of four zone pairs can be activated. However, only one zone pair can be active at any time. In the safety functional example, either zone pair 1 or zone pair 2 can be active. It is possible to switch from zone pair 1 to 2 and from zone pair 2 to 1. It depends on the cyclic output data (bit 0, bit 1, bit 2) which zone pair is active.




The following assignments apply:

| FIELD_BIT2 | FIELD_BIT1 | FIELD_BIT0 | Active zone pair | Note |
|---|---|---|---|---|
| 0 | 0 | 1 | 1 | **Implemented** in the safety functional example |
| 0 | 1 | 0 | 2 | |
| 0 | 1 | 1 | 3 | **Prepared** in the safety functional example |
| 1 | 0 | 0 | 4 | |

The states of these three bits are determined by the status of the position switches (SEN_FIELD1, SEN_FIELD2).

**Note** During zone pair switching, the PC adapter must not be connected. The PC adapter must not be plugged in at the SIMATIC FS600.

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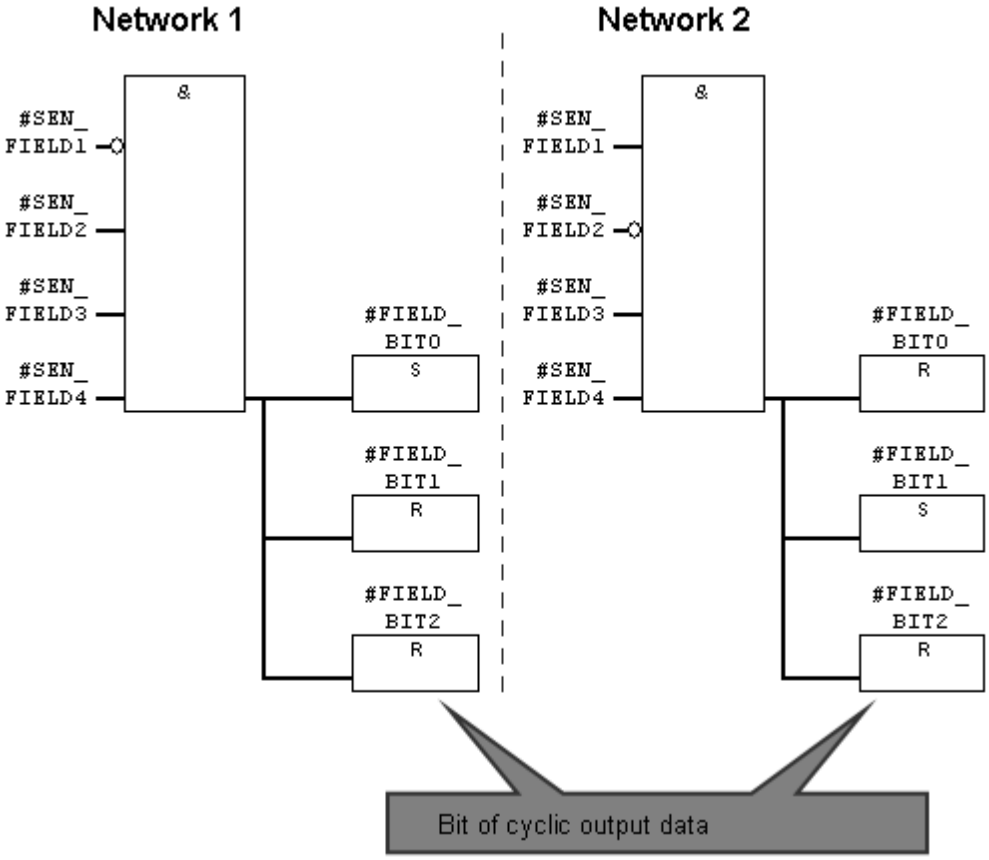
Expansion of the safety functional example

Program sequences are prepared in the sample code that allow using the zone pairs 3 and 4. Please proceed as follows:

- Parameterize the zone pairs 3 and 4 using the LS4soft configuration and diagnostics software.
- Replace the memory bits (dummies) with sensors (e.g. position switches).

**Network 1 and network 2**

The following picture shows the two networks.




**Network 3 and network 4**

In these networks the zone pairs 3 and 4 can be switched active. To do this, replace memory bits (dummies) with the sensors (input parameter at FC2) and parameterize the zone pairs in the laser scanner SIMATIC FS600 using the LS4soft configuration and diagnostics software.

**Note** The memory bits (dummies) are set by default in OB 100.

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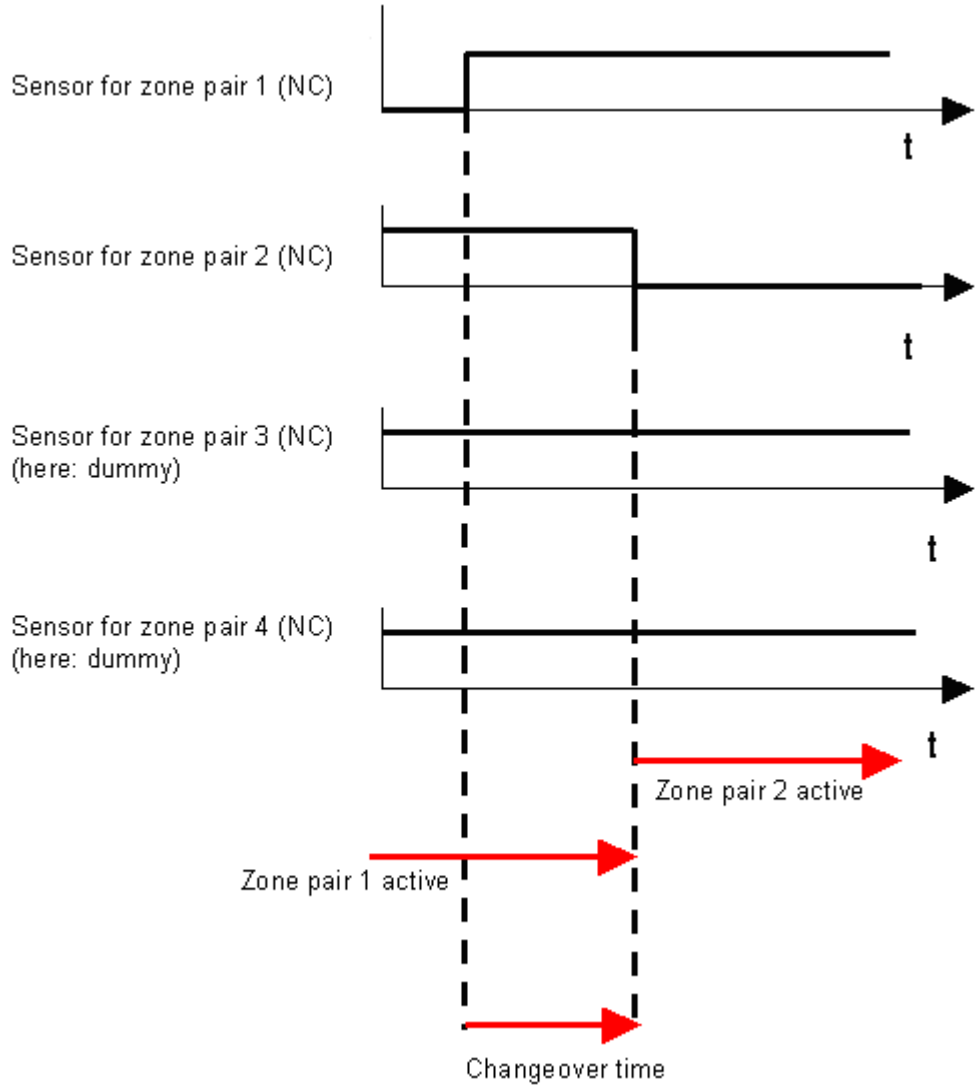
### Network 5 and network 6

A zone pair will always become active in the safety functional example if the following conditions are met simultaneously:

- the associated position switch (NC) switches (“0“ signal)
- the other position switch (NC) and the memory bits (dummies) all have the “1“ signal.

During changeover (e.g. from zone pair 1 to zone pair 2) this condition is not true for a certain duration of time. During this time the zone pair set last remains active (e.g. zone pair 1). The following figure illustrates this.

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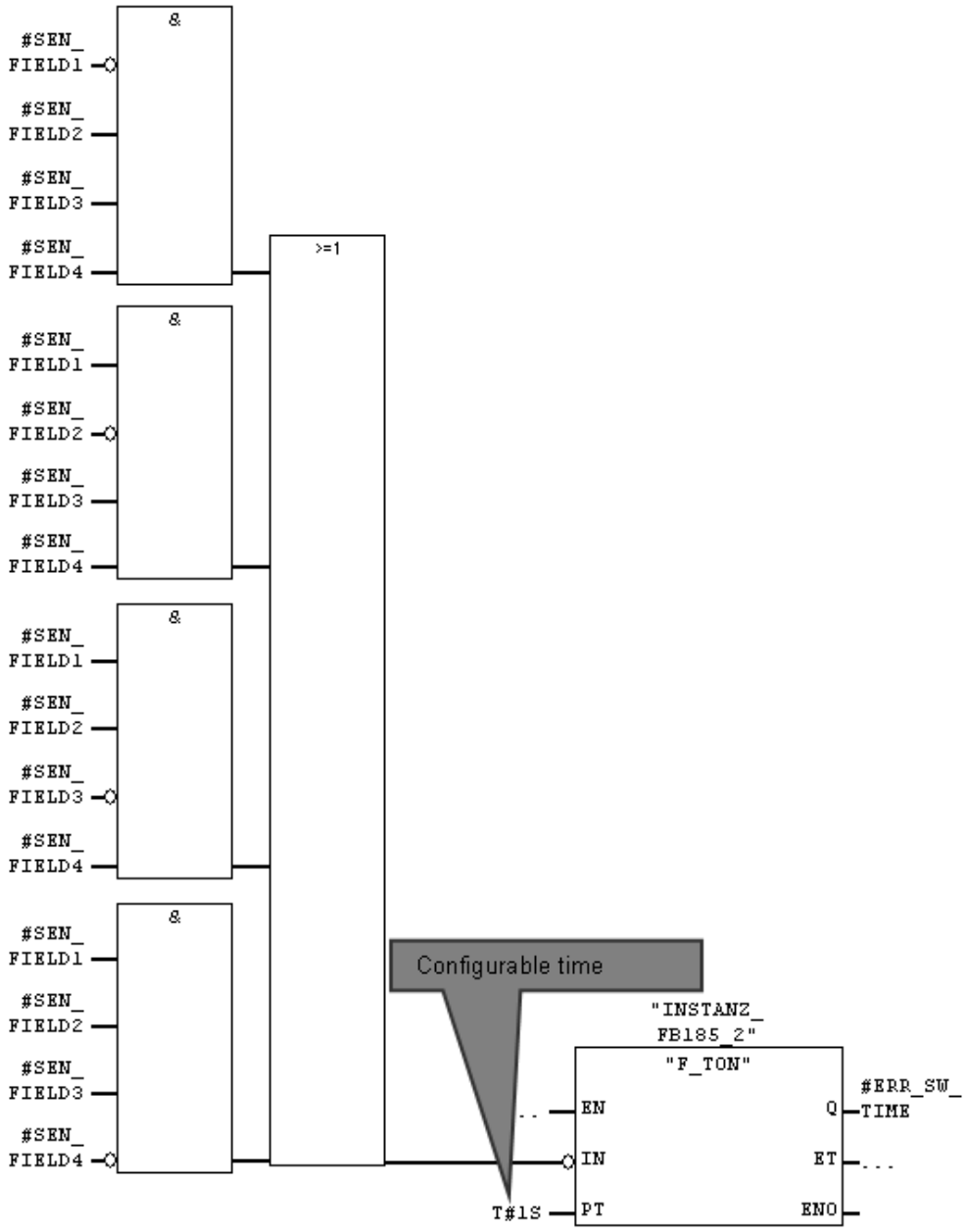
This condition can be a potential hazard depending on the application, for instance, if the sensor responsible for the changeover does not respond. In the safety functional example this condition is detected and compared with a parameterized time. If this condition continues to be true after this time has elapsed, this will be interpreted as an error and the #ERR_SW_TIME bit will be set (see network 5).

Network 5:

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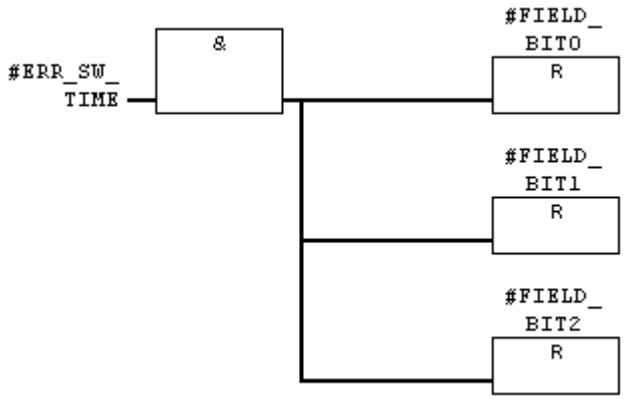
**WARNING**

**The time to be set at parameter PT of the FB F_TON depends on the application. Generally, this time should be as small as possible. For times larger than 1 sec additional safety measures should be considered.**

Network 6:

For a set #ERR_SW_TIME bit, the bits 0, 1 and 2 of the cyclic output data are reset. The bits determine which detection zone is active. Resetting these bits will cause the laser scanner SIMATIC FS600 to reset the OSSD bit. In the safety functional example, resetting the OSSD bit causes the indicator light to be switched off (see FB 3, network 1 and 2).

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## FC REINTEGRATION (FC3)

In the FC3 a re-integration is implemented for the following components:

- Laser scanner SIMATIC FS600 (network 1).
- F-DO (network 2).
- F-DI (network 3).

The memory bit #REINT is prepared for the F-DO. The F-DO is reintegrated with a positive edge at the memory bit #REINT.

**WARNING**

**In this safety functional example, passivated components are re-integrated automatically. Use the automatic re-integration for your application only if it will not cause any hazards.**

A passivation is indicated by an illuminated LED “SF” on the F module. The reintegration of an F module may take about one minute.

## 6.4 Operating instructions

Prerequisites:

- Hardware configuration and sample code of the STEP 7 project are available in the S7-CPU
- The laser scanner SIMATIC FS600 has been parameterized.
- Zone pair 1 has been set (via the two positioning switches)
- The PC adapter has not been connected
- Zone pair 1 is active
- No objects are currently in the detection zone of the laser scanner SIMATIC FS600.

The table below demonstrates the function principle:

| No. | Action | Result / Note |
|---|---|---|
| 1 | Press the push button ACK and release it | Required before starting the “machine” for the first time. |
| 2 | Press the START push button and release it | Starting (switching on) the “machine”.<br>The indicator light goes on. |
| 3 | Place an object into the detection zone | The “machine” stops.<br>The indicator light goes off. |
| 4 | Press the push button ACK and release it | An acknowledgement is required after a fault (detection zone interrupted). |
| 5 | Press the START push button and release it | Starting (switching on) the “machine”.<br>The indicator light goes on. |
| 6 | Now use the two position switches to switch from zone pair 1 to zone pair 2:<br>• FIELD_BIT0=“0“<br>• FIELD_BIT1=“1“ | Zone pair 2 is now active.<br>The changeover must take place during the time parameterized in the FB4 (network 5). |

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# 7 Evaluation acc. to EN 62061 and EN ISO 13849-1: 2006

## 7.1 Information about the standards

The following safety functional example gives an overview of EN 62061:

- http://support.automation.siemens.com/WW/view/en/23996473

For an overview of the EN ISO13849: 2006, see the following book:

- Funktionale Sicherheit von Maschinen und Anlagen.
  Umsetzung der europäischen Maschinenrichtlinie in der Praxis.
  (ISBN-13: 978-3-89578-281-7, ISBN-10: 3-89578-281-5)

## 7.2 Safety function

The following safety function is important for the further considerations:

| Safety function | |
|---|---|
| SF1 | If the detection zone is violated,<br>the “machine” must be switched off. |

This safety functional examples does not deal with the entire safety function; it focuses on certain tasks only:

| Safety function | Tasks | | |
|---|---|---|---|
| | Detect | Evaluate | React |
| SF1 | x | x | not considered **(*1)** |

Explanations on the above the table:

| (*x) | Explanation |
|---|---|
| (*1) | See safety functional example no. 7 (entry ID: 21331098):<br>Integration of the readback signal into an application<br>in category 4 according to EN 954-1: 1996 |

The two tasks mentioned above will be evaluated on the basis of the two standards EN 62061 and EN ISO 13849-1: 2006.

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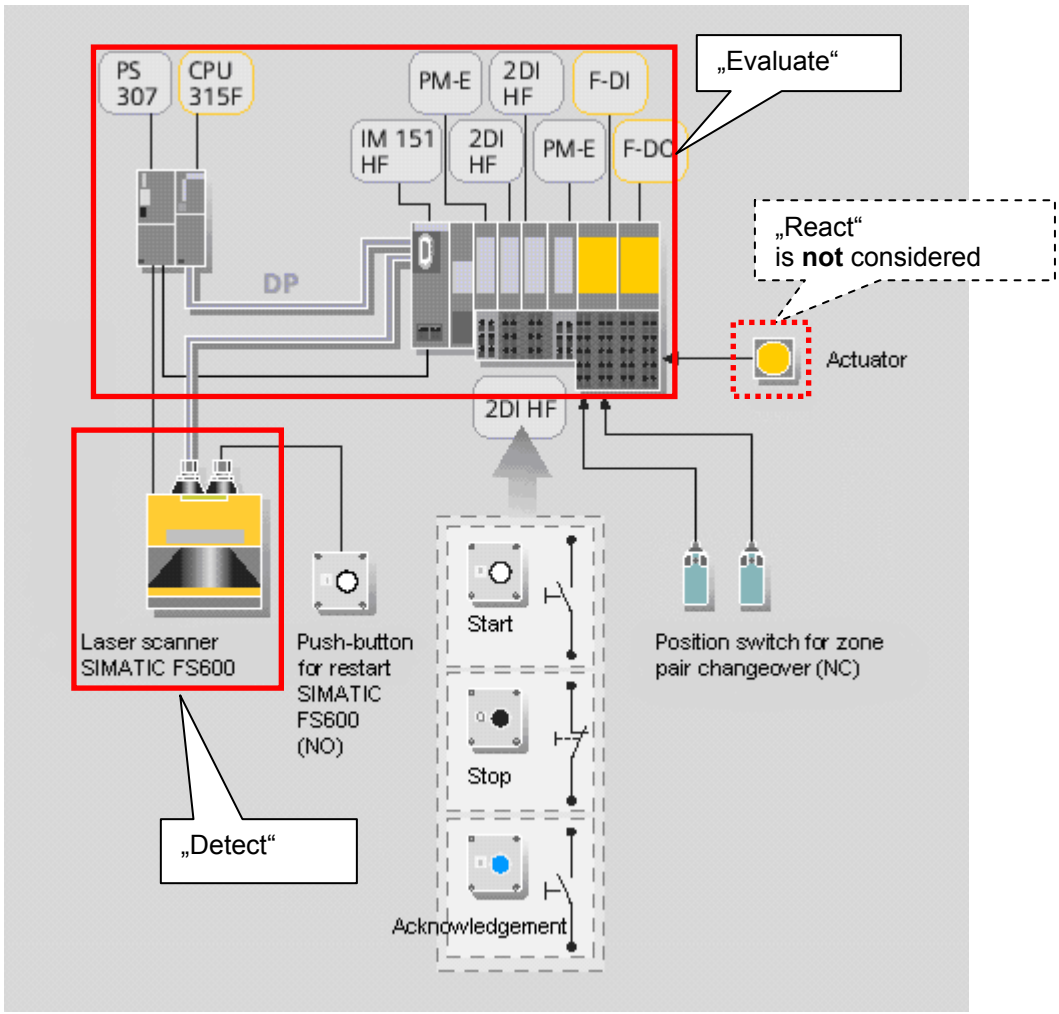
# 8 Safety Function 1

## 8.1 Mapping of the safety function

The following illustration shows the mapping of the safety function to the safety functional example:

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## 8.2 Assessment of "Detect"

### 8.2.1 Evaluation according to EN 62061

Result:

| Result | | Explanation |
|---|---|---|
| SILCL | 2 | Information of the manufacturer SIEMENS AG |
| $PFH_D$ | $8.96 * 10^{-8}$ | |

### 8.2.2 Evaluation according to EN ISO 13849-1: 2006

Result:

| Result | | Explanation |
|---|---|---|
| PL | --- | An evaluation according to EN ISO 13849-1: 2006 is not available. |
| Average probability of a hazardous failure per hour | --- | |

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## 8.3 Assessment of "Evaluate"

### 8.3.1 Evaluation according to EN 62061

Result:

| Result | | Explanation |
|---|---|---|
| SILCL | 3 | Information of the manufacturer SIEMENS AG |
| $PFH_D$ | $1.7 * 10^{-9}$ | The values for the calculation can be found in the following table. |

Values for calculating the $PFH_D$:

| Parameter | Component | Value | Definition |
|---|---|---|---|
| $PFH_D$ (F-CPU) | CPU 315F-2DP | $5.42 * 10^{-10}$ | SIEMENS AG |
| $PFH_D$ (F-I/O-module) | F-DI of the ET200S | $1 * 10^{-10}$ | |
| | F-DO of the ET200S | $1 * 10^{-10}$ | |
| $P_{TE}$ (F communication) | F Communication<br>• F-CPU and ET200S<br>• F-CPU and laser scanner SIMATIC FS600 | $1 * 10^{-9}$ | |

### 8.3.2 Evaluation according to EN ISO 13849-1: 2006

Result:

| Result | | Explanation |
|---|---|---|
| PL | e | Derived from the evaluation acc. to IEC 61508 |
| Average probability of a hazardous failure per hour | $1.7 * 10^{-9}$ | |

## 8.4 Summary

The table shows the result of the evaluation according to the two standards:

| | EN 62061 | | EN ISO 13849-1: 2006 | |
|---|---|---|---|---|
| | SILCL | $PFH_D$ | PL | Average probability of a hazardous failure per hour |
| Detect | 2 | $8.96 * 10^{-8}$ | --- | --- |
| Evaluate | 3 | $1.7 * 10^{-9}$ | e | $1.7 * 10^{-9}$ |
| React | not considered | | | |

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# 9 History

| Version | Date | Differences |
|---|---|---|
| V1.0 | 02 / 2005 | First edition |
| V2.0 | 10 / 2007 | Updating the contents regarding:<br>• Hardware and software<br>• Performance data<br>• Screenshots |
| | | New chapters:<br>• Evaluation of the safety functional example according to the new standards EN 62061 and EN ISO 13849-1: 2006 |

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